Residents Reactions to Urban Forest Disservices: A Case Study of a Major Ice Storm

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Abstract

Ecosystem services have received significant attention in the last decade, but less consideration has been given to disservices. In the urban forest, disservices include air pollution, allergens and physical damage. The way perceived and experienced urban forest disservices influence residents' tree management is unclear. This study examines residents' experiences, attitudes, and actions related to an ice storm, which created a set of urban forest disservices, to better understand the role of disservices in residents' tree management. Specifically, residents from the Greater Toronto Area were surveyed six month after the December 2013 ice storm. The survey responses indicated that the majority of participants had multiple small and large branches fall on their property, although few lost trees. As a result of their ice storm experiences, many survey participants altered their tree plans, including deciding to remove healthy trees on their property to reduce future risks. Most respondents want their municipality to continue street tree plantings, but utilize more structurally sound trees and take better care of existing trees. The case study highlights the ways disservices can influence the attitudes and actions of residents, thus, illustrating the importance of documenting disservices, along with ecosystem services, in order to develop successful management strategies.

1. Introduction

The ecosystem services produced by urban forests have received significant attention in recent years, including documentation of a long list of social, cultural, economic, health, and environmental benefits that arise from such services (Jim and Chen, 2009; Ostoića and Konijnendijk van den Bosch, 2015). These efforts parallel broader efforts to better link ecosystem functions with human well-being through the identification of positive services provided by ecosystems (MAE, 2005; TEEB, 2011). As a result of the emphasis on ecosystem services, urban forest management in North America has largely shifted from goals of beautification to ones related to maximizing ecosystem services (Silvera Seamans, 2013). The potential of service provision is then often used to justify the large investments many municipalities are currently making to grow their urban forest.

Absent from many ecosystem service discussions are the disservices produced by ecosystems. In the context of urban forests, examples of disservices include the financial costs of maintaining the urban forest, allergens, pest outbreaks, air pollution, personal safety concerns and physical damage (Escobedo et al., 2011). Recently several authors have argued the importance of examining not only the ‘goods’ but also the ‘bads’ produced by ecosystems to create a more balanced starting point for management action (Lyytimäki et al., 2008; Shapiro and Báldi, 2014). Ecosystem disservices need to be managed alongside services to maintain local support for management actions, which is particularly important in urban settings (Sandbrook and Burgess, 2015). Furthermore, exploration of disservices in urban forests should also include residents’ negative experiences with urban trees to fully understand residents’ tree management decisions (Kirkpatrick et al., 2013), develop strategies to support management goals, and/or modify goals to better reflect residents’ reaction to disservices.

This study examines residents' experiences, attitudes and actions related to a major storm event that highlighted a set of urban forest disservices. In particular, we were interested in addressing three questions: (1) what type of damage occurred to and by trees during the storm; (2) if and how the storm impacted residents' planting, pruning and removal of trees of their own property, beyond immediate clean-up; and (3) what types of municipal responses do residents support to minimize tree-related disservices associated with future storm events? These questions were explored through a case study of the December 2013 ice storm in the Greater Toronto Area (Ontario, Canada) using survey responses from residents in five neighborhoods across the region. The following sections explore the concept of ecosystem disservices, present the case study methods and results, and discuss the impact urban forest disservices have on residents' urban tree management and support.

2. Ecosystem Disservices

Several authors have recently critiqued the ecosystem services framework for only accounting for the benefits of ecosystem functions and called for integrated assessments that consider both ecosystem services and disservices (Dunn, 2010; Lyytimäki and Sipila, 2009). There is not, however, universal agreement about what disservices are (von Döhren and Haase, 2015). While a variety of definitions are also used for ecosystems services, there is greater similarity among them: typically a focus on goods or services provided by ecosystems that contribute to human well-being (MAE, 2005; TEEB, 2011). On the other hand, the term disservices is sometimes used to represent an absence or reduction of ecosystems services (Chapin et al., 2000; Harrison et al., 2014), loss of economic value associated with an ecosystem (Villa et al., 2014), or impacts from changes in an ecosystem (Balmford and Bond, 2005). Others have proposed ecosystem disservices definitions that more fully separates them from loss of benefits, with disservices characterized as functions or end-products of ecosystems that are perceived as negative for human well-being (Escobedo et al., 2011; Lyytimaki and Sipila, 2009). Through this definition, disservices can occur alongside ecosystem services and be experienced differently by individuals and communities in ways that may or may not mirror ecosystem service provision distributions (Escobedo et al., 2011). In this paper, ecosystem disservices will be used in reference to this more robust definition.

Escobedo at al. (2011) identify three main types of ecosystem disservices: financial, including land, labour, and capital; social nuisances; and environmental, including pollution and energy use associated with ecosystems and management activities. Focusing on urban areas, Lyytimäki et al. (2008) identified aesthetics, safety, security and health, economic, and mobility impacts created by ecosystem disservices.

Within the urban forestry literature, few studies have explicitly considered ecosystem disservices as more than just a reduction in ecosystem services. One exception is an analysis of both services and disservices in Melbourne (Australia), with allergen and infrastructure damage potential representing urban forest disservices (Dobbs et al., 2014). The authors found that the examined disservices were lower in public greenspaces, while higher for street trees, but the spatial patterns of both specific services and disservices varied. However, even in this analysis many more ecosystem services were accounted for (nine), while commonly identified urban forestry disservices (e.g. air pollution, maintenance costs, obscured sightlines) were excluded. The other exceptions primarily include air pollution disservices related to urban forests, with a focus on tree emissions and the energy and emissions associated with forest management (Baró et al., 2014; McPherson et al., 1998; Nowak et al., 2002; Nowak and Dwyer, 2007)

While use of the term ecosystem disservices is increasing in the literature, particularly in the context of cities (von Döhren and Haase, 2015), there is an on-going debate about the usefulness of identifying and accounting for ecosystem disservices alongside beneficial services. Opponents suggest that the current focus on ecosystems services is needed to rectify the traditional imbalance towards disservices (Shapiro and Báldi, 2014), with nature historically framed as scary and needing to be tamed. For example, there are robust literatures examining nuisance species and fear related to greenspace, both of which can be classified as disservices (Lyytimäki et al., 2008).

Villa et al. (2014) argues that inclusion of disservices adds unnecessary confusion, takes away attention from provisioning and preventative benefits, and simplifies complex interactions between humans and nature. Finally, the role of people in creating disservices is debated, with Shapiro and Báldi (2014) suggesting that most ecosystem disservices are a result of human actions (e.g. pest outbreaks due to human-aided invasions) and not products of undisturbed ecosystems.

In urban forests, many species are already not considered for planting because of their potential disservices, often related to tree debris produced or pest vulnerability (City of Burlington, 2010). Thus, one could argue that the current focus on urban forest ecosystem services is needed to encourage management away from traditional decision-making that emphasizes 'bads' and a very limited set of 'goods' (i.e. aesthetics) towards recognition of the broader set of services produced by urban forests.

Proponents argue that disservices are associated with relatively undisturbed ecosystems, as well as heavily managed or degraded systems (Lyytimäki, 2015); are necessary to account for when determining if ecosystems are an efficient way of addressing a problem (Escobedo et al., 2011); and must be examined to develop strategies to address the disservices people regular face and hear about through the media (Lyytimäki, 2014).

This last point is particularly relevant in the context of urban forests, where residents control much of the existing forest and future planting sites (McPherson, 1998; Pearce et al. 2013). While Dunn (2010) argues for a separation of perceived disservices from actual disservices, exploring residents' perceptions of ecosystem services and disservices is needed to understand their actions related to urban forest management. However, little attention has been given to residents' negative experiences with urban trees (Kirkpatrick et al., 2013), although many residents have complex attitudes towards existing trees that often vary based on the specific species and/or tree location (Conway and Bang, 2014; Kirkpatrick et al., 2012).

Residents' nuanced attitudes are often a result of context specific services and disservices; while not using these terms, many residents are well aware of disservices produced by trees. For example, in the pilot study-phase of a project asking participants to rate the level of importance they placed on different ecosystem services provided by community forests in eastern England, several negative occurrences, or disservices, were identified as missing by the pilot-phase participants (Agbenyega et al., 2009). Once these were included in the final survey, several participants placed high importance on the disservices in relation to their perception of the forests. Our study furthers the exploration of ecosystem disservices associated with urban forests by examining residents' reactions to a set of disservices created by an ice storm event.

3. Case Study: The December 2013 Ice Storm in the Greater Toronto Area

A major ice storm occurred in December 2013, affecting Southern Ontario, Quebec and the Maritimes in Canada (Armenakis and Nirupama, 2014). In the Greater Toronto Area (GTA) 30 to 50 mm of freezing rain fell between December 20th and 22nd, translating into approximately 30 mm of ice accretion on all surfaces. The weight of the ice led to numerous bent, broken, and downed trees and branches. Initial estimates indicated a 20 percent loss of canopy across the region, with 40,000 tonnes of tree debris collected as part of the storm clean-up in the City of Toronto alone (Alamenciak, 2014). Many of these damaged trees brought down utility lines, with a Toronto Hydro report indicating most power outages were from wires damaged by trees (Davies Consulting, 2014). As a result, 57 percent of customers in the City of Toronto lost power, and 10 percent were still without power seven days after the storm. In addition to trees damaging utility wires, there was also damage to personal property, with insured losses estimated at $200 million in the city (Armenakis and Nirupama, 2014).

To explore residents' experiences, attitudes and actions related to the urban forest disservices created by the ice storm, we administered a written survey in five GTA neighbourhoods (Figure 1). One neighborhood each was selected in the Cities of Brampton and Mississauga, densely populated suburbs just west of the City of Toronto. In Toronto, one neighborhood was selected in each of the Etobicoke, North York and Scarborough regions. These three areas were their own municipalities until Toronto and five neighboring municipalities amalgamated in 1998, thus they represent distinct urban forest management histories. Canopy cover extent varies between the municipalities (Table 1), but the common species are relatively consistent across the study area, with Norway Maple, White Ash, and White Spruce the most prevalent species (City of Toronto, nd; TRCA, 2011).

The study neighbourhoods were chosen based on canopy cover and housing criteria, with the goal of targeting high canopy, single-family neighborhoods. Residents in these areas likely have trees around their house, potentially receiving above average levels of ecosystem services as well as disproportionately bearing the burden of urban forest disservices. While we chose to target atypical neighborhoods, the urban forest growth plans recently adopted within the study municipalities, and many other North American municipalities, hold the potential for high canopy cover to become the norm in more neighborhoods.

Specifically, each study neighborhood represents a census tract where greater than 80 percent of homes are single-family houses and the percent canopy cover is in the municipality's top quartile for neighborhood canopy cover (Table 1). Neighborhoods were then selected that had little public land and a relatively even distribution of canopy cover across residential property. All neighborhoods have relatively high household income (Table 2), which is not surprising given the well-documented income-canopy cover relationship that exists in most urban areas (Landry and Chakraborty, 2009). However, the relatively new development and sparse canopy across the City of Brampton translates into a lower canopy cover selection criterion, as well as more moderate household income.

To assess residents' experiences and reactions to the ice storm, surveys were sent to 400 randomly selected households in each neighborhood in June 2014, six months after the storm. The survey timing means that the majority of post-storm clean-up had occurred, trees had leafed-out so residents' had a sense of their health, but the ice storm was recent enough that residents remembered damage to major branches, trees and other parts of their property. A multiple contact approach was used to help increase the response rate (Dillman, 2007). First, a letter of invitation was mailed to all potential participants detailing the research project and inviting them to complete the survey online or wait for a paper copy. A week later the paper copy was sent, with a reminder letter and second copy of the survey mailed if needed. All surveys were marked with a unique ID to help track responses by neighborhood. We asked that the person in the household primarily responsible for tree care decisions complete the survey.

Questions included basic attitudes towards urban trees, the number of trees on their property, and damage inflicted to and by trees as a result of the ice storm. We asked about property-level tree management activities the residents planned to complete over the next three years and if and how those plans changed as a result of the ice storm. To assess support for municipal action, one set of questions stated: "in response to the December ice storm, a variety of actions have been discussed as steps to reduce problems caused by future storms. Please indicate your level of support for the following," with seven statements given where respondents could indicate support using a 5-point Likert scale. As indicated, all statements reflected municipal action that were reported in local newspapers as being at least briefly considered by one or more of the city councils in response to the ice storm. The statements included additional pruning of street trees, changes in street tree planting (fewer trees, smaller stature trees, or more structurally sound trees), changes in susceptible infrastructure (burying utility wires), and helping residents' manage trees (providing monetary subsidies to residents for removal of dead and diseased trees or for tree pruning). Costs of implementing actions were not included in the survey, although clearly they are highly varied across the actions.

Completed surveys were entered into a database, and checked by a second person to eliminate errors. Summary statistics were calculated for survey questions, with survey demographics compared to data obtained from the 2011 Canadian census to assess the respondents' representativeness. Additionally, we also explored if and how answers to tree management questions varied based on household socio-demographics and extent of damage to trees during the storm. This was done through a cross-tabulation analysis, with Cramer's V as the test statistic because the variables were nominal and had more than two categories. The socio-demographic variables examined included respondent's neighborhood, gender, education-level, and immigrant status, as well as their household's income and number of household members over 64 and under 19 years of age(Table 2).

4. Results

Of the 2,000 potential participants, 81 surveys were not successfully delivered and 1,075 surveys were completed, representing a 56 percent response rate. Highest response rates were for the Etobicoke and Scarborough neighborhoods, while Brampton's response rate was the lowest. Overall the response rate was higher that mail-based surveys on similar topics, following similar methods (Larson et al., 2010; Shakeel and Conway, 2014), suggesting that the specific topic– and ability to express personal experiences and opinions about it– may have resonated with many participants. This was also evident in the number of additional comments respondents wrote on the survey, providing information beyond the specific questions we were asking; most of these comments provided elaborations about the personal impacts of the ice storm.

The participants had average household incomes that fall at or below the census tracts' averages from the 2011 census, although the representativeness of this census is unclear (Statistics Canada, 2015a), while fully detached homes are slightly over-represented in the survey sample as compared to the whole neighborhood (Table 2). Just over half of the respondents were male, with the survey requesting the person responsible for tree management decisions complete the survey, while the number who completed university is quite varied across the five neighborhoods. Twenty-four to 43 percent of respondents are immigrants to Canada. In all but Mississauga, over half of participating households included at least one senior, while 20 to 40 percent of households had at least one member under 18. In general, these participants are wealthier, better educated, more likely to be born in Canada, and older than the average resident in these municipalities (Statistics Canada, 2015b); these differences are not surprising given the selection of high canopy neighborhoods.

The average number of property-level trees varied from a low of four (Brampton) to a high of 13 (Mississauga) (Table 1), although variations within neighborhood were also quite large. When asked to identify the top three benefits provided by urban forests, most respondents chose provision of shade, production of oxygen, and their attractive appearance (Table 3). Three percent of respondents did not feel urban trees provide any benefits. On the other hand, the most commonly selected risk created by the urban forest was root damage to drains and foundation (Table 3). The next three most commonly identified risks were ones frequently experienced as a result of the ice storm: damage from falling limbs, problems with utility wires, and high costs of tree pruning and/or removal. Two percent of survey respondents selected ‘there are no risks.’

4.1 Disservices Highlighted: Damage to and by Trees

Loss of tree branches from the ice storm was widespread, while downed trees were less common (Table 4). Across all neighborhoods, 86 percent of survey respondents had one or more small branch (less than 10 feet) fall on their property, just under half had one to five large branches fall, and 23 percent of survey respondents lost five or more large branches. On the other hand, only 11 percent of residents had a tree fall on their property, and those who did typically had only one downed tree. Brampton had a slightly higher level of downed large branches and trees even though this neighborhood has less than half the canopy cover of the other study neighborhoods. The most commonly impacted trees were identified as maples and birches, both common in the study area, while 16 percent of respondents with tree debris did not know the (common or Latin) name of their damaged tree(s).

Damage to and by trees created a number of monetary and non-monetary costs for residents. Twenty-six percent of respondents hired someone to remove tree debris, and 17 percent removed standing trees that were heavily damaged by the storm. Fallen, bent, or broken branches and trees damaged other vegetation on 40 percent of respondents' property. Tree-caused damage to houses, garages, decks, and other built structures ranged from 15 to 25 percent across the five neighborhoods. Thirty-one percent of respondents in Etobicoke had damage to utility wires on their property, while in the other neighborhoods it was below 15 percent. However, loss of electricity was much more widespread: 80 percent of respondents lost electricity at some point and 38 percent, primarily located in the Etobicoke, North York and Scarborough neighborhoods, were without electricity for four or more days.

4.2 The Ice Storm`s Impact on Future Management

When asked about planting, removal and pruning plans for trees on their property, most residents do not plan on planting or removing a tree in the next three years, although across the neighborhoods 20 to 33 percent of respondents were unsure about their three-year plans (Table 5). Mississauga residents were slightly more likely to be planning additional tree planting and removal on their property, while Brampton and North York participants were less likely. In comparison to tree planting and removal, many more respondents plan on pruning their trees across all neighborhoods (65 percent to 81 percent), and far fewer residents answered 'maybe' to this question.

In response to if and how residents' property-level tree management plans had changed as a result of the ice storm, six percent of respondents no longer plan on planting another tree on their property, while eight percent made the decision to plant one or more trees because of the ice storm (Table 6). Although Brampton was the neighborhood with the fewest respondents planning to add trees in the next three years, it is also the neighborhood where the most participants changed their plans after the ice storm. Explanations for no longer wanting to plant a tree primarily focused on the ways the ice storm exposed the dangers of having trees. For example, one Mississauga resident wrote they were no longer going to plant a tree because it is "too expensive to have [trees] taken down if damaged," while a Brampton resident simply said: "[I] don't want to deal with risks associated with large trees."

Not surprisingly, those who decided to plant a tree after the ice storm primarily represented residents replacing trees lost in the storm or ones that were so damaged by the storm they were later removed. However, in many of these cases respondents indicated that the ice storm impacted the new planting site or species chosen. As one Scarborough resident stated, he planned to 'look at smaller trees (evergreens)' as replacement trees, while a North York resident wrote they "need to replace damaged trees and need to plant them in less dangerous areas in case another storm hits us."

While we did not directly ask those who lost trees if they planned on replacing them, examination of written answers explaining tree planting plans indicated that many, but not all residents, planned on replacing trees. A North York resident who lost a tree in the ice storm and does not plan on replacing it explained his position as: “the destruction trees had on the entire city after the ice storm proved that more trees means more risk of damage in the future.”

More respondents shifted their tree removal plans, with eight percent deciding not to go ahead with a planned tree removal, primarily because the unwanted tree had been removed during the storm or post-storm recovery created more pressing tree management needs. Fifteen percent of all survey respondents decided to remove a tree they were not previously going to remove, with this number including trees that were damaged during the ice storm and appeared to be suffering six months later, but excluding trees taken down within six months of the storm (typically the most severely damaged). For example, a Scarborough resident said, “we will remove one of the damaged trees - it is still alive but leaning dangerously to one side.”

However, an equally common explanation was that residents now saw the tree(s) as a threat they wanted to eliminate: “a large Chinese Elm will be removed in back yard- would also be a threat in any similar storm” wrote an Etobicoke resident. One Mississauga resident gave the reason for the new tree removal plans as “possible damage to property because of proximity to home.”

The ice storm appears to have had the largest influence on residents’ tree pruning plans, with over a quarter of respondents indicating they decided to prune the trees on their property as a result of the ice storm. This pruning included continued limb removal related to ice storm damage. For example, one Mississauga participant wrote “there are damaged areas remaining in the canopy” that she will remove. Others sought to reduce future risk through previously unplanned pruning: “the large spruce tree in the front of the house is too tall and oversized as it is too close over and above the house, and it may be subject to [future] storm damage with falling branches over the skylight" said a North York resident. A Scarborough resident simply wrote "we need to cut down big branches that can cause future damage."

In terms of support for municipal action, agreement or strong agreement was over 60 percent for the following actions: better pruning of street trees, planting more structurally sound trees, burying utility wires underground, and providing monetary subsidies to residents to cover the costs of removing diseased or dead trees (Table 7). The potential municipal actions with the highest level of disagreement were: the municipality should plant fewer street trees (80 percent disagreed or strongly disagreed) and plant street trees with a smaller mature size (41 percent disagreed or strongly disagreed). In both cases, the percent of respondents who strongly agreed with these statements was less than six percent. Most respondents were neutral or had moderate agreement or disagreement with planting smaller stature trees, and there was no clear trend for subsidies to help residents prune private trees.

Although most of the municipal statements had relatively strong response trends, the cross-tabulation analysis highlighted several patterns between support for municipal actions, household characteristics and property-level tree damage (Table 8). Mississauga participants were less likely to strongly agree with better municipal pruning, burying utility wires or monetary subsides for residents to remove trees. Gender and presence/absence of seniors in the household were both significantly related to level of agreement with four municipal actions. Specifically, males were less supportive or females were more supportive of better street tree pruning, planting more structurally sound trees, and providing subsidies to private property-owners. If seniors were present in the household, then the respondents were more likely to strongly disagree with planting fewer street trees, more likely agree or strongly agree with planting more structurally sound and planting smaller trees, and more likely to be neutral about subsidies for tree removal.

Participants who were immigrants to Canada were more likely to agree with better pruning and planting smaller trees, while respondents with higher levels of education and/or children present in the household were more likely to strongly disagree with planting fewer trees. Income, however, was not significantly related to support-level with any of the municipal actions. Finally, the respondents who lost five or more large branches during the ice storm were more likely to be strongly in agreement with the two actions related to subsidies for private landowners.

5. Discussion

The 2013 Ice Storm had widespread impacts on trees in the GTA neighborhoods included in the study. Most residents experienced at least minor damage to trees, with many having major limbs and/or trees fall on their property. The resulting disservices were primarily financial, with immediate safety and on-going aesthetic impacts. In addition to standalone disservices, the storm also likely caused a long-term reduction in ecosystem services due to canopy loss.

Exploration of broad attitudes towards trees highlighted that concerns about the types of disservices that can be caused by major storms events are seen as primary risks by residents, emphasizing the prevalence of these concerns. However, these risks were identified after the storm; unfortunately similar data is not available before the storm to see if there has been a shift in risk perception as a result of ice storm experiences. Additionally, the focus on these risks may decrease overtime, in the absence of another major storm event. Other studies have found that general tree debris is a common annoyance associated with urban trees, and some resident are concerned about the hazards created by trees and would remove a tree to reduce property damage (Camacho-Cervantes et al., 2014; Kirkpatrick et al., 2013). Thus, while we could not documented longer term risk perception trends, concerns about trees as hazards is a common, although not necessary dominant concern.

Although we are unable to examine shifts in risk perception, the survey did highlight that some residents altered planned actions as a result of the ice storm. Based on the increase in tree removals and pruning plans, residents are more aware of the potential disservices associated with trees and at least some residents have adopted proactive risk reduction strategies. While pruning, particularly when done in consultation with an expert, can contribute to the health and longevity of a tree, large limb and healthy tree removal is more concerning. Although not the majority of residents, those who plan to remove major limbs and trees based on their perceived risks are contributing to a second round of canopy loss associated with the ice storm. Thus, while the ice storm represents a discrete event, the reaction to the associated disservices appears like it will have a longer-term impact on residents and the urban forest itself.

More broadly, a risk reduction response raises questions about the long-term growth and sustainability of the urban forest that is being promoted through aggressive planting programs in many urban areas. Even if these responses are short-lived after a major storm event, regular occurrence of storms may lead to multiple waves of aggressive pruning and healthy tree removals, which means the sporadic events will have more continuous impacts.

Given the disservices experienced and removal reaction by some residents, urban forest management plans– which typical already recognize the central role of residents– should more directly identify strategies to address perceived and experienced disservices. Planting programs are usually based on increasing ecosystem services provided. In the context of post-storm planting, informing residents about a variety of trees that fared well in recent storms could encourage wary residents in re-planting efforts. In addition to tree characteristics, education about proper planting sites is needed, with many survey respondents reflecting on trees located too close to their house. Previous research indicates that some residents remove trees based on poor site selection decisions (Conway, 2015). Educating residents about site selection and species-specific ecosystem service and disservice potential before they plant a tree may discourage some from planting, but also holds the potential to reduce healthy tree removals in the future.

While some residents have reacted to storm-related tree damage, survey respondents were quite supportive of their municipality continuing to plant street trees, with the caveats they want to see better care of existing trees and preference for more structurally sound trees. These findings highlight a nuanced attitude, where people like trees but only if they pose few risks. Interestingly, respondents were less uniform in their support for the municipality planting trees that are smaller at maturity, which is at odds with recent findings regarding homeowners interest-levels related to planting and retaining tall trees (Andrew and Slater, 2014). It may be that our participants do not connect risk of falling branches to the size of the tree– possibly based on their experiences– so planting smaller stature trees is not seen as necessary. Information on the relationship between damage-levels and different sizes of trees is not available for this storm. However, tree damage was greatest in the Brampton neighborhood, which had the lowest canopy cover and generally has fewer mature trees. It is unclear if this is because of differences in the species of trees, health of trees, or local intensity of the ice storm between Brampton and the other neighborhoods.

It is difficult to compare residents' private tree management responses to the ice storm with their support for municipal action: residents may not plant additional trees because they already have the desired number, and they may not remove unwanted trees because of costs, as well as the benefits they provide (Conway, 2015). It may be that there is greater support for the municipality taking on the risk associated with trees, through street tree planting, than residents assuming the risks of private trees. Given that residents receive the benefits associated with services provided by street trees near their house but do not bear the majority of (financial) disservices, the position is in line with those who like trees but want to reduce their risk burden. Future research should explore a 'Not in My Backyard- But Yes in My Neighborhood' attitude towards trees in relation to the ecosystem services and disservices created.

The significant demographic differences in support for municipal action, in the context of strong overall response trends for many actions, are possibly related to individual ability or interest in conducting tree management tasks, and recent experiences in doing so. For example, the relatively low levels of support by males for better municipal pruning, more structurally sounds trees, and resident subsidies may indicate a willingness to accept higher risks if they feel like they are capable of pruning or removing trees and cleaning debris themselves. Unsurprisingly, households with seniors appeared more focused on lowering those disservices, with higher support for planting more structurally sounds trees and smaller stature trees.

Respondents with higher levels of education are less supportive of cost subsidies, possibly because they better understand the benefits of retaining trees or they may not perceive those costs as a burden. However, our study did not find a relationship between municipal action support and income, although that may be related to the overall high income of most participants. It is also not surprising that respondents who lost many large branches, recently bearing the physical or financial costs of removing heavy tree debris, are more supportive of the monetary subsidies for residential tree pruning and removal even though overall support was relatively ambivalent for these actions.

It should be noted that survey participants were asked to provide their level of support for these actions without a full presentation of the costs associated with implementing them. Like individual risk reduction strategies, there is the potential to decrease ecosystem services and increase disservices with several of the actions. While changing the types of species planted (to more structurally sounds or smaller stature trees) likely has the lowest impacts; on-going subsidy programs have greater costs; and burying utility wires has very substantial costs– estimated at 1.5 billion CAD for the city of Toronto alone– and also creates disservices through tree damage, required tree removals, and reduction of potential planting sites as a result of the burying.

6. Conclusions

The December 2013 ice storm created a set of urban forest disservices that impacted many GTA residents' safety and property, created time and monetary costs, and impacted landscaping aesthetics on individual properties and at broader scales. The overwhelming majority of residents in this study identified multiple benefits of urban trees, yet were also focused on the risks associated with the ice storm. In addition to general awareness of disservices, some residents are reacting to perceived or experienced disservices in their tree management decisions. In many cases these reactions will reduce the urban forest, creating a second wave of storm-related canopy loss and a reduction in ecosystem benefits.

More education about the ecosystem services provided by urban forests is often identified as a pathway to better stewardship and more urban greening (see Kronenberg 2015). However, this ignores the experiences and complex attitudes many residents already have towards urban trees. Residents are aware and often respond to ecosystem disservices, as illustrated through this case study. Thus, urban forestry researchers and practitioners cannot ignore disservices or assume that trees are universally loved, as Braverman (2008) suggests is often the case; doing so will not aid long-term growth or survival of urban forests. Instead, the ways residents perceive, experience and respond to disservices, including those produced by discrete events like major storms, need to be better understood so that practitioners can develop strategies to balance such concerns alongside ecosystem service provision.

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Table 1. Neighborhood tree conditions and survey response rates.

Neighborhood	Municipal Canopy Cover (%)	Canopy Cover Criteria	Neighborhood Canopy Cover (%)	Average Property-level Tree Count	Number of Responses (response rate)
Brampton	11	≥15%	17	4	188 (49%)
Mississauga	15	≥24%	44	13	208 (54%)
Etobicoke	26	≥38%	44	7	245 (63%)
North York	26	≥38%	50	9	197 (51%)
Scarborough	26	≥38%	49	8	237 (60%)
All Neighborhoods	N/A	N/A	N/A	7	1075 (56%)

Table 2. Household characteristics of survey respondents.

Neighborhood	Fully Detached Houses (%)	Respondent Characteristics			Household Characteristics		
		Male (%)	Immigrant (%)	University Degree or Higher (%)	Average Income (CAD)	One or more person ≥ 65 (%)	One or more person ≤ 18 (%)
Brampton	58	55	42	39	60 000 - 89 000	59	40
Mississauga	99	63	24	55	90 000 – 119 000	44	35
Etobicoke	100	56	24	72	150 000 – 179 000	52	26
North York	98	63	43	83	120 000 – 149 000	57	20
Scarborough	97	53	37	51	90 000 – 119 000	55	20

Table 3. Perceived benefits and risks created by the urban forest, summarized by percent of respondents who listed each in their top three.

	Brampton	Mississauga	Etobicoke	North York	Scarborough	All Neighborhoods
Benefits						
Provide shade in yard or garden	75	65	66	62	66	66
Provide oxygen	69	54	60	60	61	60
Trees look attractive	32	41	42	44	41	40
Combat global warming effects	31	38	24	30	28	30
Provide food and shelter for animals	45	30	16	24	29	28
Reduce noise or sight lines	28	31	26	22	22	26
Lower heating or cooling costs	32	34	19	16	23	24
Create a calming effect	24	28	21	19	12	21
Increase property value	20	27	24	13	12	19
Stabilizing the Soil	21	14	15	20	12	16
Other	1	0	0	0	0	0
There are no benefits	3	2	4	3	2	3
Risks						
Root damage to drains or foundation	78	64	67	71	80	72
Harm from falling branches	64	70	61	56	60	62
Problems with utility wires	46	49	64	49	54	53
High costs for pruning/removal	33	50	32	36	40	38
Root damage to hard landscaping	46	25	20	30	34	30
Tree leaves/flowers create a mess	28	24	18	14	13	19
Attract unwanted animals/insects	19	11	9	7	8	11
Create unsafe areas for criminal activity	13	10	4	2	1	6
Creates shade in yard or garden	14	13	2	3	4	7
Other	8	10	6	10	3	7
There are no risks	3	2	2	2	1	2

Table 4. Percent of respondents with fallen branches and trees on their property.

Neighborhood	Small Branches (< 10 ft)	Larger Branches (≥ 10 ft)				Trees		
		None	1 to 5	6 to 10	More than 10	None	1 to 2	3 to 4
Brampton	86	21	49	14	16	86	14	1
Mississauga	89	39	41	14	6	90	10	0
Etobicoke	94	33	45	11	10	91	9	0
North York	87	37	44	11	7	89	9	2
Scarborough	85	33	43	14	11	90	10	0
All Neighborhoods	86	34	44	13	10	87	10	1

Table 5. Survey respondents tree planting, removal, and pruning plans over the next three years, by percent.

Question	Answer	Brampton	Mississauga	Etobicoke	North York	Scarborough	All Neighborhoods
Do you plan to plant a tree in the next 3 years?	Yes	18	27	24	16	18	21
	No	57	39	50	60	53	51
	Maybe	25	33	26	24	28	27
Do you plan to remove a tree in the next 3 years?	Yes	12	26	21	11	20	18
	No	66	47	51	65	61	56
	Maybe	21	27	28	24	20	24
Do you plan to prune your trees in the next 3 years?	Yes	68	78	81	78	65	73
	No	22	8	7	8	15	12
	Maybe	9	14	13	14	19	14

Table 6. Percent of respondents who changed plans as a result of the ice storm. Unaccounted for percentages not included in table are residents whose plans have not changed.

How Plans Changed		Brampton	Mississauga	Etobicoke	North York	Scarborough	All Neighborhoods
Planting plans changed	No longer acting	8	5	6	6	8	6
	Now taking action	11	7	10	5	8	8
Removal plans changed	No longer acting	9	6	9	9	7	8
	Now taking action	15	11	21	11	14	15
Pruning plans changed	No longer acting	3	2	2	1	4	2
	Now taking action	26	26	30	28	21	26

Table 7. Level of support for different potential municipal actions, by percent of responses, with all neighborhoods aggregated.

Level of Support	Better pruning and care of street trees	Plant fewer street trees	Plant street trees that are more structurally sound	Plant street trees smaller in stature	Utilities should be buried	Subsidies to remove diseased/dead/ damaged trees	Subsidies to prune trees
Strongly Agree	38	2	17	5	48	34	23
Agree	40	4	45	14	34	36	25
Neutral	14	13	28	39	13	12	19
Disagree	6	36	7	32	2	12	22
Strongly Disagree	3	44	3	9	2	6	10

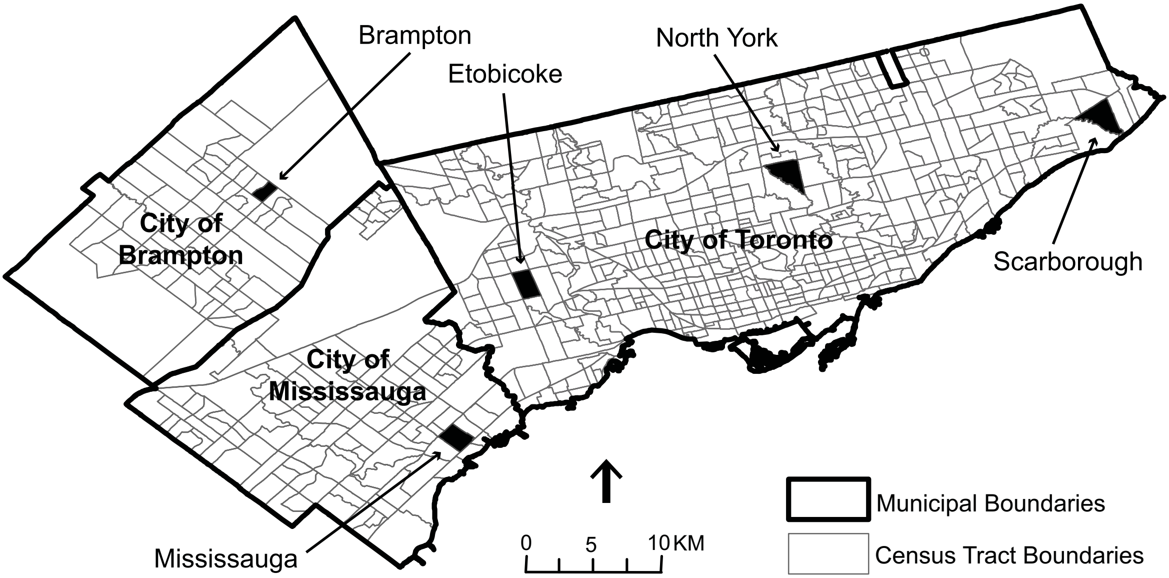
Table 8. Significant relationships between level of support for municipal actions and neighborhood, household demographics, and property-level ice storm damage. Numeric value is Cramer's V statistic. * p-value ≤ 0.05, ** p-value ≤ 0.01, *** p-value ≤ 0.001

Variable	Better pruning and care of street trees	Plant fewer street trees	Plant street trees that are more structurally sound	Plant street trees smaller in stature	Utilities should be buried	Subsidies to remove diseased/dead/ damaged trees	Subsidies to prune trees
Neighborhood	0.114*** Mississauga less likely to strongly agree				0.108*** Mississauga less likely to strongly agree	0.087* Mississauga less likely to strongly agree	
Gender	0.102 * Males more likely to disagree		0.166 *** Females likely to more strongly agree			0.153*** Females more likely to strongly agree	0.161*** Females mote likely to strongly agree
Education (five categories)		0.082* Greater Education, More strongly disagree				0.101** Greater Education, Less strongly agree	
Immigrant to Canada	0.099* Immigrants more likely to strongly agree			0.174*** Immigrants more likely to strongly agree			
Household member(s), Over 65		0.125** Seniors present more likely to strongly disagree	0.111* Seniors present more likely to strongly agree	0.171*** Seniors present more likely to agree		0.107*** Seniors present more likely neutral	

Household member(s), Under 18	0.127** Children present more likely strongly disagree		0.120** Children present more likely strongly disagree	0.125** Children present more likely neutral, disagree		
No. of large branches lost					0.200*** 5-10 or 10+ branches more likely to strongly agree	0.190*** 5-10 or 10+ branches more likely to strongly agree

Figures

Figure 1. The five study neighborhoods located within the Greater Toronto Area.


Brampton
North York
Etobicoke
City of Brampton
City of Toronto
City of Mississauga
Scarborough
Mississauga
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